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Diversity, uses and exploitation impacts of plant-based Non-Timber Forest Products (NTFPs) in the Rural Commune of Bounouma, Republic of Guinea.

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Abstract

This study investigates the diversity, ethnobotanical uses, economic contribution, and degradation factors affecting Non-Timber Forest Products (NTFPs) of plant origin in the Rural Commune of Bounouma, Guinea. The methodology combined floristic inventories conducted in major harvesting areas, semi-structured ethnobotanical surveys with households, and an economic assessment based on income generated from NTFPs. Direct observations and interviews with local actors were also used to evaluate the pressures exerted on these resources.

Results reveal a high diversity of NTFPs, dominated by trees and shrubs, followed by herbaceous species and lianas. These resources are primarily used for traditional medicine, food, and handicrafts. Multipurpose species such as *Elaeis guineensis*, *Raphia hookeri*, *Garcinia kola*, and *Xylopia aethiopica* play a central role in household subsistence strategies. The Diécké Classified Forest represents the main source of harvesting, confirming its ecological and socio-economic importance for local populations.

Economically, the processing and commercialization of NTFPs generate substantial income for rural households, particularly through the sale of rattan, palm kernel cake, and local fruits, thus contributing to food security and community resilience. However, the study highlights increasing pressure on several vulnerable species due to traditional farming practices, uncontrolled harvesting, and insufficient management regulations.

A notable finding is the functional differentiation among villages (some specializing in primary collection and others in processing and value addition) which enhances value chain efficiency and maximizes socio-economic benefits. Overall, the results stress the need for sustainable management strategies that integrate conservation, economic valorization, and rural development in the Bounouma region.

Keywords: Non-Timber Forest Products, Economic valuation, Biodiversity conservation, Rural livelihoods, Bounouma.

Introduction

Forest ecosystems are a fundamental pillar of socio-economic well-being for rural communities worldwide. Beyond their recognized ecological functions (such as climate regulation, soil protection, biodiversity conservation, and the provision of essential ecosystem services) forests constitute a critical source of livelihoods and income for local populations (FAO, 2015; Belcher *et al.,* 2005). Among the most strategic components of these ecosystems are Non-Timber Forest Products (NTFPs), including fruits, nuts, edible leaves, resins, mushrooms, and medicinal plants. Their significance is particularly pronounced in areas where economic alternatives are limited and where livelihood diversification relies heavily on natural resources (Shackleton and Pandey, 2014; Chao, 2020).

In West Africa, Non-Timber Forest Products (NTFPs) constitute a major component of the rural economy and make a substantial contribution to household food and nutritional security. They also serve as an important avenue for women's economic empowerment, as women are often the primary actors in the collection, processing, and marketing of these resources (Shackleton *et al.,* 2011). Nevertheless, the development and sustainable use of NTFPs in the region face significant challenges, including rising anthropogenic pressures, deforestation, land conversion to agriculture, and the impacts of climate change, which disrupt regeneration cycles and affect the seasonal availability of key resources (Ingram *et al.,* 2017, FAO, 2018).

In the Republic of Guinea, the Rural Commune (CR) of Bounouma, located in the Prefecture of N'Zérékoré, exemplifies this dynamic. The area, characterized by remarkable biodiversity and strengthened by the presence of the Diécké Classified Forest, hosts a wide variety of Non-Timber Forest Products (NTFPs) that are used for food, medicinal, cultural, and commercial purposes (Dupont *et al.,* 2015; Kouyaté and Diallo, 2018 ; Diallo, 2020). These practices, transmitted across generations, reflect a long-standing tradition of local use and management of forest resources, as emphasized by Koné and Traoré (2021), CIFOR (2020), Traoré (2020), and Dupont and Koffi (2019). However, despite the central role of NTFPs in household subsistence strategies, their socio-economic contributions remain insufficiently documented at the local scale. This knowledge gap hampers the formulation of informed public policies, the strengthening of natural resource governance, and the promotion of sustainable exploitation strategies.

Furthermore, growing demographic pressures, the expansion of agricultural land, unregulated harvesting, and the intensification of human activities pose major threats to the sustainability of NTFPs in this area. Similarly, the effects of climate change (seasonal fluctuations, increase in extreme events, changes in phenological calendars) are leading to reduced availability and increased variability of resources, compromising the livelihoods of households dependent on NTFPs.

In this context, analyzing the diversity, ethnobotanical uses, and economic contributions of plant-based Non-Timber Forest Products (NTFPs) is essential for understanding their actual role in shaping rural household incomes, quantifying the benefits derived from their exploitation, and identifying the risks that may

threaten their sustainability. A comprehensive understanding of local dynamics is particularly crucial, as NTFPs serve as a strategic tool for poverty alleviation, enhancing community resilience to climate change, and promoting sustainable forest management, as highlighted by Kouadio *et al.* (2020) and INRAE (2021). Moreover, increasing anthropogenic pressures and unsustainable harvesting practices can diminish resource availability, underscoring the need to assess the degradation factors that influence the long-term sustainability of NTFPs in the area.

This study aims to address this knowledge gap by: [1]identifying and cataloging the diversity of plant-based NTFPs in the Rural Commune of Bounouma; [2]analyzing the ethnobotanical uses and valorization practices of NTFPs by local communities; [3]assessing the economic contribution of NTFPs to households through the income generated across key areas of ethnobotanical use; and [4]examining the factors related to harvesting, anthropogenic pressure, and degradation that may influence the sustainability of NTFPs in the study area.

Materials and Methods

Geo-economic characteristics of the Rural Commune of Bounouma

The Rural Commune (CR) of Bounouma, located in the Prefecture of N'Zerekore in Guinea Forestière, lies approximately between 8°25' and 8°50' north latitude and 9°15' to 9°35' west longitude (MATD, 2021). It covers an area of about 272 km² and has a population of nearly 25,000 inhabitants, distributed across twenty-four villages organized into ten districts and fourteen administrative sectors, resulting in an average population density of 81 inhabitants per km² (RGPH, 2014). The commune is bordered to the east by the CR of Yalenzou, to the west by the CR of Samoé, to the north by the Urban Municipality of N'Zerekore (CUZ), and to the southwest by the CR of Diécké and the Liberian border.

The physical environment of the area is typical of the forested region, featuring a landscape of hills, gently undulating plateaus, and deep valleys. The climate is tropical and humid, with a rainy season extending from May to October and a dry season from November to April. Annual rainfall ranges between 2,000 and 2,500 mm, supporting a dense and diverse vegetation cover (FAO, 2019). The natural vegetation comprises both primary and secondary forests, which harbor remarkable biodiversity, including primates, numerous bird species, and endemic plant taxa.

The hydrographic network of the Rural Commune of Bounouma is dominated by the Gbolo River and its main tributaries. These waterways serve as vital resources for crop irrigation, drinking water supply, and various domestic activities. They also play a key ecological role, shaping landscape dynamics and supporting local biodiversity (PNDES, 2020). The local economy is primarily based on subsistence agriculture, focusing on rice, cassava, bananas, coffee, and cocoa, alongside traditional livestock farming, gathering, crafts, local trade, and forestry activities (Bounouma Local Development Plan, 2021). However, economic development in the commune is constrained by inadequate infrastructure, particularly rural roads, processing facilities, and access to basic social services. Despite these limitations, some localities, including Gossopa, Manawi, Kéréma, Yossonon, and Koipa, are witnessing a notable increase in the exploitation of plant-based Non-Timber Forest Products (NTFPs) (Figure 1).

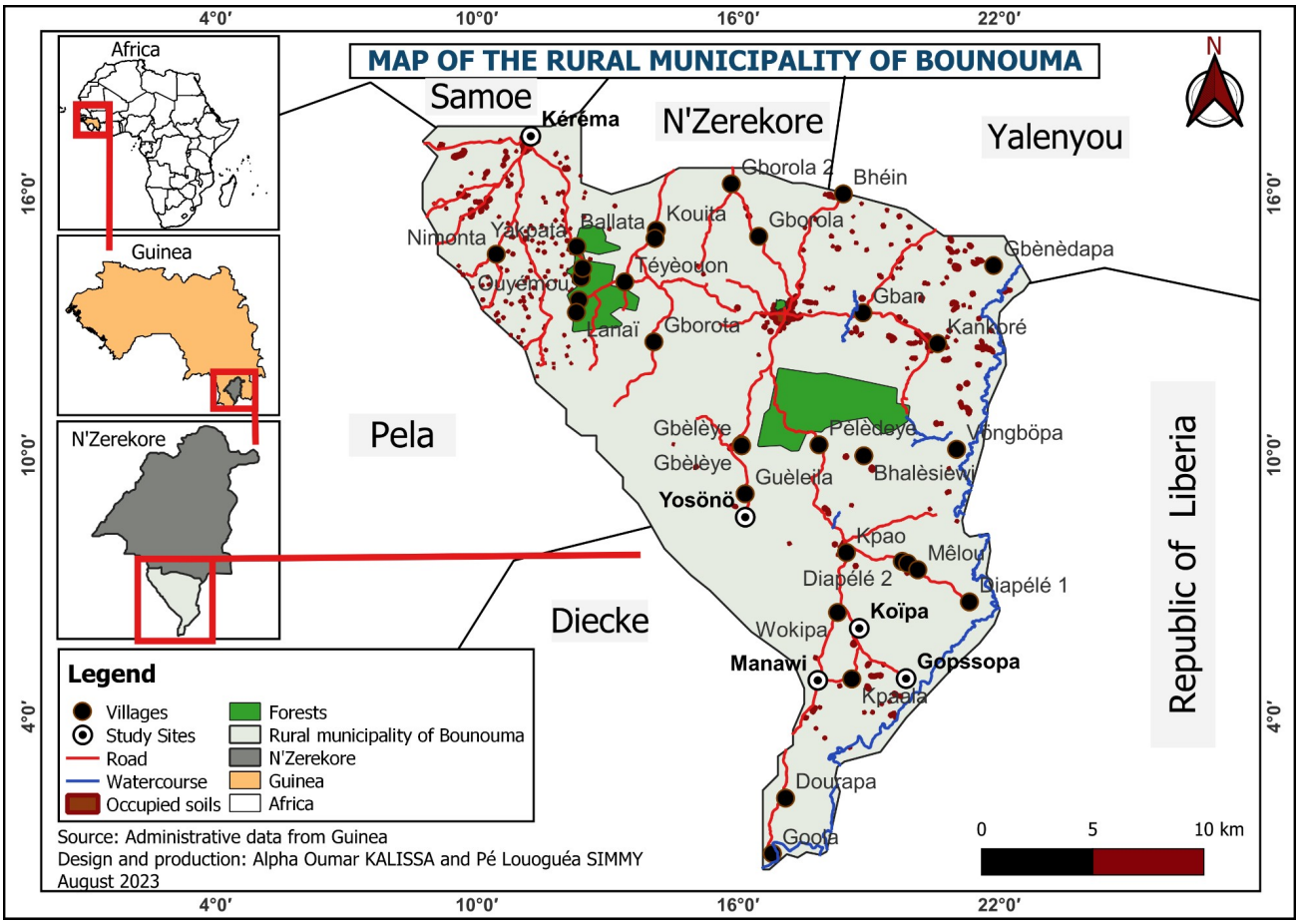

Figure 1. Location of study sites in the Bounouma CR, Guinea.

Sampling

The first phase of the study involved documentary research, which included consulting documents on NTFPs at the N'Zerekore Environmental Research Center (CREDEZ), the N'Zerekore University Library, the N'Zerekore Forestry Center (CFZ), and the Nimba Mountains Scientific Station (SSMN). Additionally, websites of international organizations, such as the Convention on Biological Diversity (CBD), Sud-Expert Plants, UNDP, FAO, and IUCN, were reviewed to integrate normative frameworks and global references on forest resources. Informal discussions with field experts further enriched the research. This documentary review informed the development of structured questionnaires aimed at collecting detailed information on the socio-economic dimensions of NTFP use and management.

The study was carried out in the villages of Bossou Centre, Gossopa, Manawi, Kéréma, Yossonon, and Koipa, all located within the Rural Commune of Bounouma (Figure 1). These villages were selected using a purposive sampling approach due to their proximity to the Diécké classified forest and their high dependence on non-timber forest products (NTFPs). The field survey involved the collection of both qualitative and quantitative data. Qualitative data were obtained through informal and semi-structured interviews with key informants and experienced actors with in-depth knowledge of NTFP use and valorization. Quantitative data focused on production statistics, income, and profits generated from NTFP activities by households and local actors. The sample size for the Rural Commune of Bounouma was calculated using Dagnelie's formula (1998), which takes into account the proportion of households utilizing NTFPs as a livelihood resource. The formula is expressed as follows:

$$n = \frac{Z^2 \cdot P \cdot (1 - P)}{E^2}$$

Where:
n = sample size.
Z = confidence level derived from the confidence rate (traditionally 1.96 for a rate of 95%).
P = estimated proportion of actors using NTFPs as resources.
E = acceptable margin of error (the value of 5% is used).

Applying the formula with P= 0.5 yielded a total of 141 peoples, whose distribution by sampled village is shown in Table 1.

Table 1: Socio-professional identification variable of respondents by target group

Riverside villages explored	Number of people surveyed	Breakdown by Gender		Age group			Socio-professional category			
		M	F	23-34	45-56	57≥	Ar.	Tp.	A.C.	A.L
Bounouma Center	76	21	55	46	21	9	48	23	2	3
Gossopa	15	5	10	10	4	1	8	4	2	1
Manawi	17	6	11	10	5	2	10	5	1	1
Kéréma	13	6	7	7	4	2	6	5	1	1
Yossonon	9	2	7	6	3	0	5	2	1	1
Koipa	11	6	5	5	5	1	4	5	1	1
Under total	141	46	95	84	42	15	81	44	8	8
Total		**141**		**141**			**141**			

Legend: Ar. = Artisans; Tp. = Traditional practitioners; AC = Conservation agents; AL = Local authorities.

Data collection methodology

The data collection methodology consisted of gathering data using three complementary tools: semi-structured interviews, structured questionnaires, and direct observations.

Semi-structured interviews

Semi-structured interviews were conducted to collect qualitative data on exploitation practices, local perceptions of NTFPs, and perceived changes in resource availability. Seven focus group discussions, each comprising 3 to 5 participants, were organized across the different villages. Priority was given to traditional practitioners, including artisans, healers, and herbalists, due to their extensive local knowledge and experience. The discussions explored the types of NTFPs utilized, observed temporal and spatial changes in availability, and the management practices employed to ensure sustainable use of these resources.

Structured questionnaires

Structured questionnaires were administered individually to 16 participants, primarily comprising conservation officers and local authorities. The purpose was to collect quantitative data to compare institutional and community perceptions regarding the importance, utilization, and management of NTFPs within their respective constituencies. This approach allowed for the systematic documentation of differences and convergences in perspectives on NTFP governance, use patterns, and socio-economic significance.

Direct observations

Direct and participatory observations were conducted to document agricultural practices, the condition of natural resources, and interactions between local populations and their environment. This approach complemented the data obtained from interviews and questionnaires by providing objective, first-hand information on the biophysical context and on-the-ground practices related to the use and management of NTFPs.

Data analysis

Qualitative data from the interviews were transcribed and analyzed using NVivo 12 software, following the methodology proposed by Paillé and Mucchielli (2016), to identify recurring themes, stakeholder perception differences, and major trends. Quantitative data were processed using descriptive statistics (frequencies, means, standard deviations) in Excel (version 2013). This mixed-methods approach allowed for: (i) the comparison of perceptions among different stakeholder groups; (ii) the identification of factors influencing the exploitation and management of NTFPs; (iii) the quantification of the contribution of NTFPs to local livelihoods; and (iv) the construction of a profitability matrix to characterize the intensity of NTFP use in the Rural Commune of Bounouma.

Results

Identified Non-Timber Forest Products (NTFPs) of plant origin

The inventory conducted in six villages of the Rural Commune of Bounouma identified 53 plant-based NTFP species, distributed across 28 botanical families (Table 2). This diversity underscores the floristic richness of the area and emphasizes the ecological, economic, and sociocultural significance of these resources for local communities.

Table 2: Summary of NTFPs of identified plant origin

No	Scientific name	Common name (Manon)	Family	Morphological type	Status IUCN, 2018
1	*Champignons*	Toro	Agaricaceae	-	-
2	*Anacardium ocidentalis*	Somo	Anacardiaceae	Shrub	LC
3	*Maghifera indica Linn., 2012*	Magolo		Tree	LC
4	*Xylopia aethiopica (Dunal) A. Rich., 2012*	Ghanh	Annonacea	Tree	LC
5	*Xylopia staudtii Engl & Diels, 2019*			Tree	LC
6	*Xylopia villosa Chipp., 2003*	Gbaanpulu		Tree	LC
7	*Landolphia dulcis (R. Br) Pichon, 1953*	Kpovouakara	Apocynaceae	Vine	LC
8	*Rauvolfia vomitoria Afzel, 1817*	Moyayiri		Shrub	LC

9	*Alstonia boonei De Wild., 1914*	Yoro		Tree	LC
10	*Funtumia africana (Benth.) Stopf, 1899*	Sékélé		Tree	LC
11	*Culcasia angolensis P.Beauv 1803*	Moubelegwon	Araceae	Herbaceous plant	VU
12	*Cercestis afzelii Schott., 1857*	Moubeleh		Herbaceous plant	LC
13	*Laccosperma acutiflorum (Becc.) J. Dransf. 1982*	Kpah	Arecaceae	Vine	LC
14	*Elaeis guineensis Jacq. 1963*	Ton-yiri	Arecaceae	Tree	LC
15	*Raphia hookeri G.Mann & H.Wendland., 1864*	Yoh-yiri		Tree	VU
16	*Ageratum coconyzoides*	Davoe-leh	Asteraceae	Herbaceous plant	LC
17	*Bidens pilosa*	Gbe		Herbaceous plant	LC
18	*Carica papaya*	Blan guin	Caricaceae	Shrub	LC
19	*Garcinia minitifolia Engl*	Soniyiri gwan	Clusiaceae	Tree	VU
20	*Terminaria ivoriensis A. Chev., 1909*	Bei	Combretaceae	Tree	LC
21	*Terminaria superba Engl & Diels, 1899*	Beiban		Tree	VU
22	*Ricinodendron heudelotii Mull.Arg 1864*	Koho	Euphorbiaceae	Tree	LC
23	*Alchornea cordifolia (Schumach. & Thonn.) Müll. Arg., 1865*	Fla-leh		Herbaceous plant	LC
24	*Parkia bicolor A Chev., 1966*	Komi	Fabaceae	Tree	EN
25	*Harungana madagascariensis Lam. Ex Poir, 1804*	Lolo	Guttiferae	Tree	LC
26	*Persea americana Mill., 1768*	Voka	Lauraceae	Tree	LC
27	*Cola cordifolia (Cav.) R. Br., 1844*	Boba	Malvaceae	Tree	LC
28	*Triumfetta cordifolia*	Zan		Herbaceous	LC

29	*Megaphrynium macrostachyum (Benth.) Milne-Redh*	Gaa	Marantaceae	Herbaceous	LC
30	*Thaumatococus danielli*	Saa		Herbaceous	LC
31	*Sarcophilynium prionogonium*	Saan		Herbaceous	EN
32	*Limnophyton angolense*	Bolo	Meliaceae	Herbaceous	VU
33	*Carapa procera DC., 1824*	Bbon		Tree	LC
34	*Ficus on*		Moraceae	Tree	LC
35	*Pycnanthus angolensis*	Dini	Myristicaceae	Tree	LC
36	*Piper guineensis Thonn Schum & Thonn., 1827*	Zèmèlè	Piperaceae	Vine	LC
37	*Anadelphia afzeliana (Rendle) Stapf., 1919*	Dainh	poaceae	Herbaceous	VU
38	*Morinda longiflora G.Don*	Zologbo	Rubiaceae	Herbaceous	LC
39	*Nauclea latifolia Smith, 1753*	Weinyiri		Shrub	LC
40	*Coffea arabica L. 1753*	Café		Shrub	LC
41	*Geophila obvallata (Schumach.) Didr.*	Kuokola-leh		Herbaceous	LC
42	*Hymenocoleus hirsutus (Prance) Sothers 2016*	Kuokola-leh		Shrub	LC
43	*Craterispermum laurinum (Poir) Benth., 1849*	Gbèkè		Shrub	LC
44	*Zantehoxylum gilleteii Engl*	Gein	Rutaceae	Tree	LC
45	*Blighia welwitschii*	Glein	Sapindaceae	Tree	LC
46	*Baillonella toxisperma J.Baptiste L. pierre 1890*	Louroulè	Sapotaceae	Tree	VU

47	*Solanum torvum Sw., 1789*	Nawan-leh	Solanaceae	Shrub	VU
48	*Cola nitida*	Goh	Sterculiaceae	Tree	LC
49	*Garcinia cola Heckel, 1883*	Soniyiri		Tree	VU
50	*Theobroma cacao Linn., 1985*	Cacao		Shrub	LC
51	*Aframomum longicapomum Hook. F. Schum, 1904*	Douandi	Zingiberaceae	Herbaceous	LC
52	*Aframomum latifolium Afz, 1783*	Sen		Herbaceous	LC
53	*Costus afer*	Zin		Shrub	LC

The table shows that the 53 NTFP species recorded in the Rural Commune of Bounouma belong to 28 botanical families and exhibit considerable morphological diversity, including trees, shrubs, lianas, and herbaceous plants. This distribution reflects the area's rich flora and highlights the complexity of its forest ecosystems. The most represented families are Annonaceae, Arecaceae, Fabaceae, Rubiaceae, and Clusiaceae, which include species of high economic, nutritional, medicinal, and artisanal value. The biological forms are dominated by woody species (trees and shrubs), underscoring the importance of the tree strata as the primary sources of NTFPs, while herbaceous plants and lianas complement the supply of food, medicinal, and craft resources. Regarding conservation status, most species are classified as Least Concern (LC) according to the IUCN (2018), yet eight species are Vulnerable (VU) and two are Endangered (EN), including *Parkia bicolor*, *Raphia hookeri*, and *Baillonella toxisperma*, indicating the ecological vulnerability of certain heavily exploited NTFPs. Furthermore, the coexistence of strictly forest species and agroforestry species such as *Elaeis guineensis*, *Theobroma cacao*, and *Carica papaya* illustrates the linkage between natural forest collection and village-based production systems. This integration contributes significantly to household food security and economic resilience, demonstrating the dual ecological and socio-economic importance of NTFPs in the region.

Ethnobotanical uses of identified NTFP organs

The 53 NTFP species identified in the Rural Commune of Bounouma exhibit a remarkable diversity of ethnobotanical uses, primarily distributed among traditional medicine, food, crafts, and construction. The most frequently utilized plant parts are the leaves, bark, fruits, and roots, underscoring their central role in local cultural practices and the transmission of traditional knowledge (Table 3). This diversity of use highlights the multifunctional value of NTFPs for the livelihoods and well-being of the communities.

Table 3: Ethnobotanical uses of identified NTFP organs

N°	Scientific name	Parts used								Use			
		Fe	E	T	Fr	G	R	N	S	Phr	Fo	Ar	Const
1	*Landolphia dulcis (R. Br) Pichon, 1953*	X		X	X		X			*X*	X	*X*	
2	*Landolphia hirsuta (Hua) pichon, 1953*	X		X	X		X			*X*	*X*	*X*	
3	*Rauvolfia vomitoria Afzel, 1817*	X	X				X	X		*X*			
4	*Alstonia boonei De Wild., 1914*		X				X			*X*	X		
5	*Funtumia africana (Benth.) Stopf, 1899*	X	X	X						*X*	X		
6	*Elaeis guineensis Jacq. 1963*	X	X	X	X	X	X	X	*X*	*X*	X	*X*	*X*
7	*Raphia hookeri G.Mann & H.Wendland., 1864*	X	X	X	X	X	X	X	*X*	*X*	X	*X*	*X*
8	*Cola nitida*	X			X			X		*X*			*X*
9	*Garcinia cola Heckel, 1883*				X			X					*X*
10	*Theobroma cacao Linn., 1985*	X			X					*X*			
11	*Cola cordifolia (Cav.) R. Br., 1844*												
12	*Triumfetta cordifolia*		X		X					*X*			
13	*Piper guineensis Thonn Schum & Thonn., 1827*	X		X	X					*X*			
14	*Aframomum longicapomum Hook. F. Schum, 1904*	X		X			X			*X*			*X*
15	*Aframomum latifolium Afz, 1783*	X		X			X			*X*			*X*
16	*Costus afer*						X			*X*			
17	*Garcinia minitifolia Engl*	X	X	X			X			*X*			
18	*Megaphrynium macrostachyum (Benth.) Milne-Redh*	X								*X*			
19	*Thaumatococus danielli*	X	X							*X*		*X*	
20	*Sarcophilynium prionogonium*	X			X					*X*		*X*	*X*
21	*Baillonella toxisperma J.Baptiste L. pierre 1890*	X	X							*X*			*X*
22	*Ricinodendron heudelotii Mull.Arg 1864*	X	X			X		X		*X*			
23	*Alchornea cordifolia (Schumach. & Thonn.) Müll. Arg., 1865*	X		X	X					*X*	*X*		

24	*Xylopia aethiopica (Dunal) A. Rich., 2012*				X					*X*			
25	*Xylopia staudtii Engl & Diels, 2019*				X					*X*			
26	*Xylopia villosa Chipp., 2003*				X					*X*			
27	*Morinda longiflora G.Don*	X	X			X				*X*			
28	*Nauclea latifolia Smith, 1753*	X	X		X	X				*X*			
29	*Coffea arabica L. 1753*				X								
30	*Geophila obvallata (Schumach.) Didr.*	X								*X*			
31	*Hymenocoleus hirsutus (Prance) Sothers 2016*	X								*X*			
32	*Craterispermum laurinum (Poir) Benth., 1849*	X	X	X						*X*		*X*	
33	*Parkia bicolor A Chev., 1966*		X		X					*X*			
34	*Anadelphia afzeliana (Rendle) Stapf., 1919*	X	X								*X*		
35	*Terminaria ivoriensis A. Chev., 1909*	X	X							*X*	*X*	*X*	
36	*Terminaria superba Engl & Diels, 1899*	X	X							*X*	*X*	*X*	
37	*Limnophyton angolense*	X	X							*X*			
38	*Carapa procera DC., 1824*				X					*X*			
39	*Culcasia angolensis P.Beauv 1803*	X	X							*X*		*X*	
40	*Cercestis afzelii Schott., 1857*	X								*X*			
41	*Ageratum coconyzoides*	X		X	X	X				*X*			
42	*Bidens pilosa*	X		X		X				*X*			
43	*Solanum torvum Sw., 1789*	X		X	X					*X*		*X*	
44	*Zantehoxylum gilletii Engl*		X			X				*X*		*X*	*X*
45	*Pycnanthus angolensis*	X	X				X			*X*			
46	*Persea americana Mill., 1768*	X								*X*			
47	*Anacardium ocidentalis*				X					*X*			
48	*Maghifera indica Linn., 2012*	X	X		X					*X*			
49	*Blighia welwitschii*	X								*X*			

50	*Carica papaya*	X			X	X				*X*			
51	*Ficus sur*	X	X		X	X				*X*			
52	*Harungana madagascariensis Lam. Ex Poir, 1804*				X					*X*			
53	*Mushrooms*		X							*X*			

Legend: Fe= leaf; E= bark; T= stem; fr= fruit; G= seed; R= root; N= nut; S= sap Phr=Pharmacopoeia; Const= Construction; Ar= crafts; Fo= Food

Analysis of Table 2 indicates that traditional medicine represents the primary use of NTFPs, characterized by a high demand for leaves, bark, and roots. Certain key species, notably *Elaeis guineensis* and *Raphia hookeri*, are particularly versatile, with their various parts employed across multiple categories of use. Food-related applications rely mainly on the fruits and seeds of *Cola nitida*, *Garcinia kola*, *Mangifera indica*, and *Carica papaya*, underscoring the critical contribution of these species to household nutrition and food security. Craft and construction uses, which are more specialized, involve species that provide fibers, leaves, or woody materials for domestic and technical purposes. Overall, the distribution of NTFP uses reflects the strong dependence of rural communities on forest resources and highlights the necessity of implementing sustainable management strategies focused on the most frequently exploited species to ensure long-term availability and ecosystem resilience.

Sources of harvested NTFPs identified

All 53 identified plant-based NTFP species originate from the Diécké classified forest, forest galleries, agroforestry plantations, lowland areas, and fallow lands. According to the responses of the 141 participants surveyed, more than half of these NTFPs are sourced directly from the Diécké classified forest (Figure 2), highlighting its central role as a primary reservoir of biodiversity and a critical resource base for local communities.

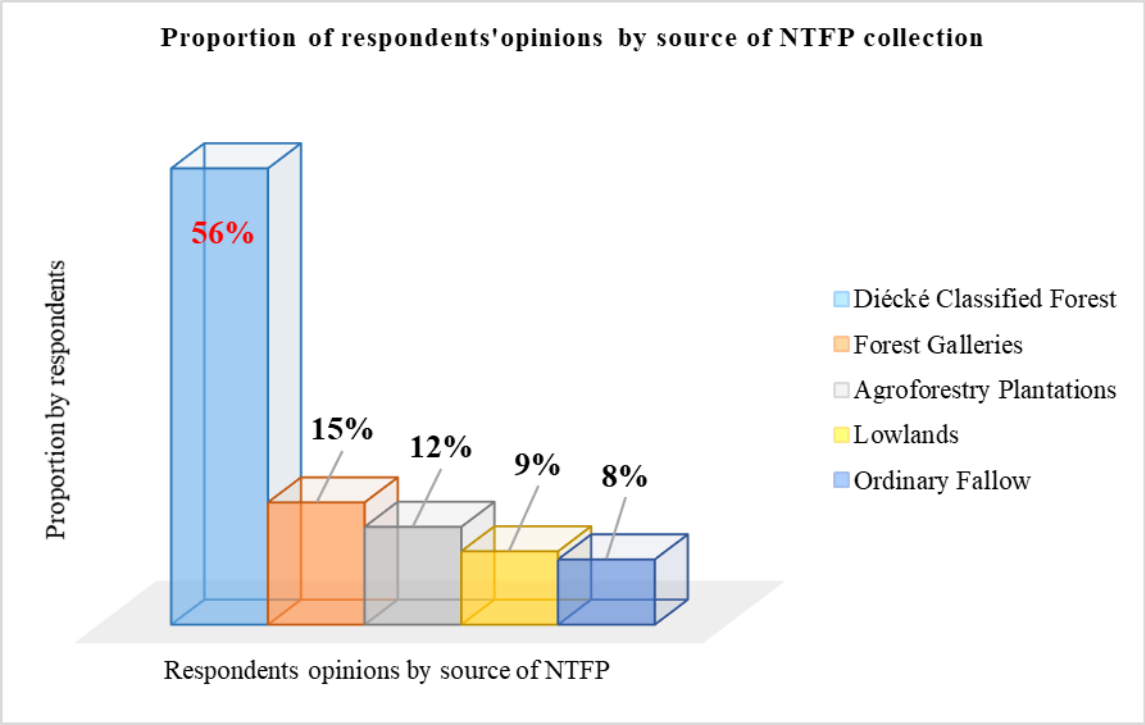

Figure 2: Proportion of respondents' opinions by source of NTFP collection

Analysis of Figure 2 indicates that the Diécké classified forest is the primary source of NTFPs, accounting for 56% of responses. This dominance underscores the forest's central role in supplying plant-based NTFPs to local communities, reflecting both its high species richness and the strong dependence of households on this natural resource. Secondary sources include forest galleries (15%), agroforestry plantations (12%), lowlands (9%), and ordinary fallow lands (8%). This distribution highlights that, while anthropized and semi-natural habitats contribute to NTFP supply, their role remains subordinate to that of the classified forest, emphasizing the importance of sustainable management strategies focused on the primary forest.

Production and utilization of NTFPs by village visited

The villages studied have different ways of organizing NTFP-related activities, reflecting local specializations in the value chain for these resources. The villages of Gossopa, Manawi, Yossonon, and Koipa are mainly involved in NTFP production and collection, while the villages of Bounouma Centre and Kéréma focus more on processing and marketing (Table 4).

Table 4: Status of production and utilization of NTFPs by village

Villages studied	Type of activity	Main NTFPs produced/processed	Main use	Proportion of production/ processing
Gossopa	Production	*Elaeis guineensis, Raphia hookeri, Cola nitida*	Pharmacopoeia, food	25%
Manawi	Production	*Garcinia kola, Mangifera indica, Carica papaya*	Food, pharmacopoeia	16%
Yossonon	Production	*Elaeis guineensis, Raphia hookeri*	Pharmacopoeia, crafts	21%
Koipa	Production	*Cola nitida, Garcinia kola*	Food, pharmacopoeia	15%
Bounouma center	Transformation / Valorization	*Raphia hookeri, Elaeis guineensis*	Pharmacopoeia, crafts, and food	11%
Kéréma	Transformation / Valorization	*Mangifera indica, Carica papaya*	Food, pharmacopoeia	6%

Analysis of Table 2 highlights a differentiated distribution of NTFP-related activities across the villages studied. Gossopa, Manawi, Yossonon, and Koipa are primarily engaged in the collection and production of NTFPs, with production shares ranging from 15% to 25%. Key species exploited in these villages include Elaeis guineensis, Raphia hookeri, Cola nitida, Garcinia kola, Mangifera indica, and Carica papaya, which are utilized for food, medicine, and craft purposes. In contrast, Bounouma center (11%) and Kéréma (6%) focus mainly on processing and valorization, producing derivatives for dietary, medicinal, and artisanal uses. This differentiation of roles demonstrates a localized division of labor that enhances the efficiency of NTFP exploitation, optimizes resource utilization, and reinforces household subsistence strategies and the rural economy.

Economic contribution of NTFPs by ethnobotanical use

Analysis of income generated from the processing of Non-Timber Forest Products (NTFPs) reveals substantial variability in earnings, depending on the species exploited, the type of products derived, and the level of processing applied.

All producers surveyed recognize the economic importance of NTFPs and the crucial role they play in their livelihoods (Table 5).

Table 5: Summary of producer revenues by area of use

Designations	Quantity NTFP /Week	Expenses	Selling price /unit	Total Amount	Half-yearly income/fg	Monthly income/fg	Annual income/fg
Garcinia kola	13kg	6000	60 000	780 000	774 000	3 096 000	9 288 000
Xylopia aethiopica	9kg	5000	30 000	270 000	265000	1 060 000	3 180 000
Rattan	2 tas	30 000	100 000	200 000	170 000	680 000	8 160 000
Thaumatococus danielli	3tas	-	35 000	105 000	105 000	420 000	5040 000
Triumfetta cordifolia	50tas	5000	1000	50 000	45 000	180 000	2160 000
White wine	7bidons	70 000	40000	280 000	210 000	840 000	10 080 000
Palm seeds	25tas	-	2000	50 000	50 000	200 000	1 200 000

Analysis of income generated by NTFPs in the rural commune of Bounouma (Table 5) indicates that these resources play a significant role in supporting local livelihoods. Products such as *Garcinia kola*, *Xylopia aethiopica*, rattan, *Thaumatococus danielli*, *Triumfetta cordifolia*, white wine, and palm seeds generate variable income depending on production quantities, selling prices, and associated costs. Among these, *Garcinia kola* and white wine constitute the main sources of income, with estimated annual revenues of 9,288,000 FG and 10,080,000 FG, respectively, highlighting their importance in food, medicine, and local trade. Other products, including *Xylopia aethiopica*, rattan, and palm seeds, provide substantial, though comparatively lower, earnings, reflecting the diversification of economic opportunities enabled by NTFP exploitation. Mushrooms and *Triumfetta cordifolia* generate the least income. This variation in revenue underscores differences in resource availability, market value, and production intensity, emphasizing the need for sustainable management strategies to optimize both economic benefits and resource conservation.

Factors contributing to the degradation of Non-Timber Forest Products (NTFPs)

Practices such as monoculture, traditional agriculture, and illegal harvesting of NTFPs have been identified as major factors contributing to the degradation of NTFPs in the rural commune of Bounouma (Table 6).

Table 6: Perception of factors contributing to the degradation of NTFPs by village

Village	No. surveyed	Traditional agriculture (Nb / %)	Monoculture (Nb / %)	Illegal harvesting (Nb / %)
Bounouma Center	76	42 (55 %)	23 (30 %)	11 (15 %)
Gossopa	15	8 (55 %)	5 (30 %)	2 (15 %)
Manawi	17	9 (53 %)	5 (29 %)	3 (18 %)
Kéréma	13	7 (54 %)	4 (31 %)	2 (15 %)
Yossonon	9	5 (56 %)	3 (33 %)	1 (11 %)
Koipa	11	6 (55 %)	3 (27 %)	2 (18 %)
Total / Average	**141**	**77 (55 %)**	**43 (30 %)**	**21 (15 %)**

Analysis of the perceptions of the 141 respondents indicates that traditional agricultural practices are the primary driver of NTFP degradation (55%), followed by monoculture (30%) and illegal harvesting (15%). This pattern is consistent across the surveyed villages, underscoring the significant pressure exerted by local farming activities on forest resources. Although less frequently reported, illegal harvesting occurs in all villages, suggesting sporadic but persistent exploitation. Overall, these findings confirm that the degradation of NTFPs is largely linked to local agricultural practices, highlighting the need for sustainable land-use strategies and community-based resource management to mitigate pressure on these vital forest resources.

All processors (artisans, traditional practitioners, and consumers) interviewed recognize the profitability and satisfaction associated with products made from NTFPs in the Bounouma CR (Table 6).

Table 7: Summary of local processors' revenues by item

Designation	Items	Number /S/M	Expenses	Selling price/U/ FG	Total amount/ FG	Half-yearly income/ FG	Monthly income/ FG	Annual income/ FG
Rotin (*Calamus rotang*)	Rattan shelf	1	365 000	750 000	750 000	385 000	1540 000	18 480 000
	Armchair	1	1 225 000	1 900 000	1 900 000	-	675 000	8 100 000
	Wind	4	77 000	40 000	160 000	83 000	332 000	3 984 000
	Rattan belt	8	105 000	37 000	296000	191 000	764 000	9 168 000
Thaumatococcus	Mat	1	25 000	120 000	120 000	95 000fg	380 000	4 560 000
Elaeis guineensis	Ballet	9	4500	3000	27000	22 500	90 000	1 080 000
	Red oil	3 bidons de 20L	60 000	130 000	390 000	330 000	1320 000	7920 000
	Palm kernel cake	5 sacs	30 000	200 000	1000 000	970 000	3 880 000	15 000 000
	Local fishing net	1	5000	45 000	45000	40 000	80 000	9 60 000
Raphia hookeri (raphia)	Fish trap	4	13 000	20 000	80 000	67 000	268 000	3 216 000
	Aviary	3	23 000	15 000	45 000	22 000	88 000	1 056 000
	Ballet	12	5000	4 000	48 000	43 000	172 000	2064 000

Table 7 shows that the processing of NTFPs constitutes a vital source of income, with highly profitable value chains such as rattan, which generates up to 18.48 million FG per year, and oil palm, whose cake produces approximately 15 million FG per year. Products such as red palm oil (7.92 million FG/year) and rattan belts (9.17 million FG/year) further confirm this profitability. Lower but steady incomes from raphia and Thaumatococcus (ranging from 1 to 4.56 million FG/year) also contribute to stabilizing household economies in the local communities.

Discussion

This study highlights the richness and diversity of non-timber forest products (NTFPs) in the Rural Commune of Bounouma, confirming the central role of the Diécké classified forest as a reservoir of biodiversity and essential resources for local communities. These findings are consistent with observations by FAO (2015) and Belcher *et al.* (2005) in West Africa and Indonesia, where NTFPs serve simultaneously as ecological, nutritional, and economic resources. The predominance of trees and shrubs underscores the importance of tree strata, while herbaceous plants and lianas complement the supply of food, medicinal, and artisanal resources.

The recorded uses show that NTFPs are primarily exploited for traditional medicine, followed by food and craft applications, confirming their multifunctional role in household subsistence strategies. Multipurpose species such as Elaeis guineensis and Raphia hookeri are key pillars of household resilience, in line with the observations of Shackleton and Pandey (2014) for tropical forests in South Africa and those of Ingram (2017) in the Democratic Republic of Congo and Cameroon.

Fruits and seeds of *Cola nitida, Garcinia kola*, *Mangifera indica,* and *Carica papaya* contribute directly to nutritional security, corroborating the findings of Diallo (2020) in Guinea. Regarding resource sources, the classified forest remains the primary supplier (56% of responses), while agroforestry plantations and semi-natural habitats play a secondary role. This distribution emphasizes the need to implement integrated and sustainable forest management strategies that reconcile local exploitation, biodiversity conservation, and food security (Kouyaté and Diallo, 2018).

The economic assessment indicates that the processing and valorization of non-timber forest products (NTFPs) provide significant sources of income for households. Products such as rattan and palm kernel cake generate notable annual earnings, confirming that the sustainable exploitation of NTFPs is a key lever for rural development and economic resilience, as highlighted by Belcher *et al.* (2005) and Shackleton and Pandey (2014) in various contexts within the sub-region.

However, NTFP exploitation, combined with traditional agricultural practices, exerts pressure on vulnerable species such as *Parkia bicolor*, *Raphia hookeri*, and *Baillonella toxisperma*, underscoring the urgency of implementing conservation strategies and regulating harvests (Ingram, 2017). Nevertheless, the coexistence of forest and agroforestry species could reconcile food security, economic utilization, and conservation objectives, necessitating sustainable management models that integrate village-level production, economic valorization, and forest protection.

Furthermore, the differentiation of roles among villages (where some focus on primary collection while others specialize in processing and valorization) optimizes resource use and maximizes socio-economic benefits (Belcher *et al.,* 2005). This local organization reflects a territorially adapted strategy that could serve as a model for other rural regions, balancing biodiversity conservation, food security, and sustainable rural development.

Conclusion

The study revealed that the Rural Commune of Bounouma hosts a remarkable diversity of non-timber forest products (NTFPs), with the Diécké classified forest serving as the main source. The identified NTFPs are widely used for traditional medicine, food, and artisanal purposes, contributing significantly to household food security and income. The processing and valorization of certain products, such as rattan and palm kernel cake, generate substantial revenues, thereby reinforcing rural development and the economic resilience of local communities.

However, pressure from traditional agriculture and the harvesting of vulnerable species underscores the urgent need for conservation

strategies and sustainable management practices. Furthermore, the differentiation of roles among villages (where some focus on primary collection while others specialize in processing and marketing) illustrates the importance of an optimized, territorially adapted organization that reconciles economic exploitation with forest resource protection.

Overall, the results confirm that the effective and sustainable management of NTFPs requires contextualized and integrated strategies combining biodiversity conservation, food security, and socio-economic development. These findings provide practical insights for forest planning and rural development in Guinea.

Author Contributions

The first author collected, processed, and drafted this article. The other authors contributed to the writing of this article.

Data Availability Statement

Data are contained within the article.

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Conflicts of Interest

The authors declare no conflict of interest.

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